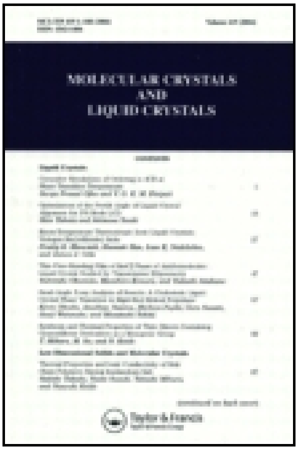

Molecular Crystals and Liquid Crystals Science and Technology. Section A. Molecular Crystals and Liquid Crystals

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gmcl19

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Version of record first published: 24 Sep 2006

To cite this article: Tae-Woo Lee, O. Ok Park, Hyun Nam Cho, Jae-Min Hong & Young Chul Kim (2001): White Emission from a Polymer Blend Light-Emitting Diode by Incomplete Cascade Energy Transfer, Molecular Crystals and Liquid Crystals Science and Technology. Section A. Molecular Crystals and Liquid Crystals, 371:1, 435-438

To link to this article: http://dx.doi.org/10.1080/10587250108024777

Mol. Cryst. and Liq. Cryst., 2001, Vol. 371, pp. 435-438

White Emission from a Polymer Blend Light-Emitting Diode by Incomplete Cascade Energy Transfer

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White light emission was obtained from a polymer light-emitting diode (LED) made of a ternary polymer blend comprised of poly(9-vinylcarbazole) (PVK), poly(9,9'-dihexlyfluorene-2,7-divinylene-*m*-phenylenevinylene-stat-*p*-phenylenevinylene) (CPDHFPV), and poly[2-methoxy-5-(2'-(ethyl-hexyloxy)-1,4-phenylenevinylene) (MEH-PPV) (19:1:1 by wt.). Incomplete cascade energy transfer was employed to obtain white emission from the polymer blend LED. Compatibility between PVK and CPDHFPV facilitated the Förster-type energy transfer from PVK to CPDHFPV. However, poor compatibility between CPDHFPV and MEH-PPV resulted in a partial energy transfer between the polymers causing the blend to emit two colors simultaneously. Consequently, pure white color near CIE coordinate (0.33, 0.33) could be obtained with a low sensitivity to the drive voltage.

Keywords electroluminescence; white emission; energy transfer

INTRODUCTION

Many researchers have been interested in white light-emitting devices because they have important applications such as an illumination light source or a backlight for liquid crystal displays. Until now, several ways to produce whitish light from polymeric or organic small molecule devices have been demonstrated: multi-layer devices composed of several different materials, which emit the primary RGB colors [1] and blend of multi-component materials, which is an easier method to produce white emission [2-3]. Here, we employ *incomplete cascade energy transfer* for white emission from a ternary polymer blend. We investigated a 19/1/1(w/w/w) blend of poly(9-vinylcarbazole) (PVK), poly(9,9-dihexyl fluorene-2,7-divinylene-*m*-phenyl-enevinylene-stat-*p*-phenylenevinylene) (CPDHFPV), and poly[2-methoxy-5-(2'-(ethyl-hexyloxy)-1,4-phenylenevinylene) (MEH-PPV). All the component are not completely miscible with one another; PVK and CPDHFPV are miscible but CPDHFPV and MEH-PPV, and PVK and MEH-PPV are poorly miscible.

RESULTS AND DISCUSSION

The spectral overlaps both between PVK and CPDHFPV, and between CPDHFPV and MEH-PPV are observed. This meets the necessary condition for Förster energy transfer [4]. Therefore, we can expect the cascade energy transfer from PVK to MEH-PPV when the average intermolecular distance between the materials is less than the Förster radius [5]. Figure 1(a) shows the photoluminescence (PL) spectra of the blend excited at 340, 380, and 500 nm, which correspond to the absorption peak wavelengths of PVK, CPDHFPV, and MEH-PPV, respectively. Figure 1(b) shows PL excitation spectra of the blend film measured at the emission wavelengths of 475 and 590 nm, which correspond to the emission peak of CPDHFPV and MEH-PPV, respectively. The PL excitation (PLE) spectrum measured at 475 nm shows that the emission of CPDHFPV mainly originates from the excitation energy transferred from PVK. On the other hand, the PLE spectrum measured at 590 nm suggests that the emission of MEH-PPV can be triggered by the excitation of any component, PVK, CPDHFPV, or MEH-PPV, of the ternary blend. We can clearly observe that the excitation energy of MEH-PPV in the blend is transferred from CPDHFPV as well as directly from PVK in part. Consequently, we obtain the two colors emitted simultaneously from CPDHFPV and MEH-PPV, blue and orange red, respectively, in the ternary blend. Therefore, we consider that our blend system generates white emission by an incomplete cascade energy transfer.

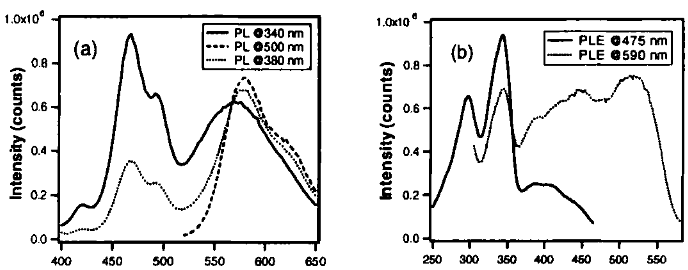

FIGURE 1 (a) PL and (b) PL excitation spectra of PVK/CPDHFPV/MEH-PPV (19/1/1 by wt.) blend.

We measured the current-voltage-luminance characteristics of the LED made of the polymer blend. The luminance of the ITO/(PVK/CPDHFPV/MEH-PPV) blend/Al device reaches about 620 cd/m^2 at 20 mA as shown in FIGURE 2. The external quantum efficiency of the device is 0.09% photons/electrons.

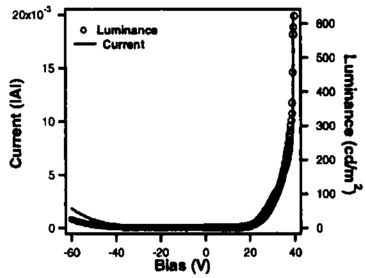

FIGURE 2 Current-voltage-luminance curves of the EL device.

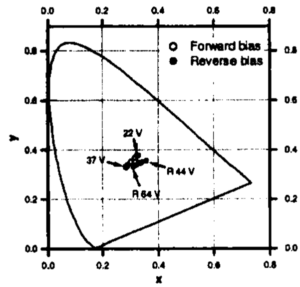

FIGURE 3 CIE 1931 (x,y) chromaticity diagram of the EL device.

Figure 3 shows the 1931 Commission Internationale d'Eclairage (CIE) chromaticity diagram of the light emitted from the ternary polymer blend device measured while applying forward or reverse bias. Pure white color near CIE coordinate (0.33, 0.33) could be obtained from the blend EL device. The emission color varied slightly with the applied potential. Incomplete cascade energy transfer is also responsible for the white emission with a low sensitivity to the drive potential.

In summary, white electroluminescence insensitive to the driving voltage can be successfully achieved from a ternary polymer blend device of PVK, CPDHFPV, and MEH-PPV by incomplete cascade energy transfer.

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